To the Commissioner of Patents & Trademarks:

This is an application for Letters Patent of the United States of America on an invention entitled

APPARATUS FOR IN-SITU REMEDIATION USING A CLOSED DELIVERY SYSTEM

by Michael Scalzi of Doylestown, Pennsylvania and Wade Meese of Worthington, Ohio, both citizens of the United States of America.

APPARATUS FOR IN-SITU REMEDIATION USING A CLOSED DELIVERY SYSTEM

The present application is related to provisional patent application serial number 60/437,981 entitled "Apparatus for In-Situ Remediation Using a Closed Delivery System" filed on January 6, 2003, priority from which is hereby claimed.

FIELD OF THE INVENTION

The present invention relates to apparatus for the sub-surface injection of remedial liquids, slurries and colloidal suspensions to treat impacted groundwater and soils.

BACKGROUND OF THE INVENTION

There are many methods and apparatus purposed for the treatment of contaminated matter. Burying the material, incineration, vacuum extraction, and microbial mineralization are just a few available options. Burying the waste is commonly how radioactive and recalcitrant materials are treated. Solids are deposited in shallow trenches about three meters wide and between three and five meters deep. When the waste is filled to about one meter from the top of the trench, the trench is covered with earth. A large volume of heterogeneous contamination is produced by such waste which may continuously seep into the soil and water. Incineration is another available option. The purpose of incineration is to burn off the contaminants and leave only the clean soil. However, this may be a very expensive process and not very feasible if large volumes of soil need to be treated. Also, it may have pollution side effects of vapor and air pollution while the soil is being removed and moved to the incineration site. Soil Vacuum Extraction (SVE) is a simple and economical treatment method, however organochloric compounds in a concentration of several ppm or lower may not be readily removed when entrained within clays or loams. Further channeling is frequently found within a SVE system,

further reducing the system's overall efficacy. Lastly, many compounds with poor Henry's Constants will not be efficiently removed via an SVE approach. This physical approach remediation process requires time in annual scale.

In order to solve the problems with the above-described methods, biological or in-situ oxidation processes have been devised. Critical to any in-situ injection process is the efficient delivery of materials to the targeted area or zone. Frequently materials may be injected by way of a cylindrical delivery rod with an expendable point. This point is pushed out to allow for pumped material to escape from the base of the injected point. In-situ remediation allows for petroleum hydrocarbon, chlorinated solvents, metals and radonuculi to be treated without any digging of the soil, so it can be performed where other treatment approaches may not be practical.

In order to perform in-situ treatments, an apparatus for delivery is needed. The most common and practical is a steel injection rod forced into the soil which causes preferential pathways when materials are forced from its terminus, often along the interface between the rod and the soil. These pathways prevent efficient application of remedial materials to the target zone. To alleviate this problem, a hollow injection rod with lateral discharge holes allows for liquids to be injected into the contaminated material and, when performed well, in-situ injections are not only practical but also very economical. However, problems exist, for example switching between feed systems cannot be accomplished without loss of pressure to the delivery line. The resulting vacuum causes the delivery pathways to close and results in reduced lateral distribution of delivered materials. It is because of these problems experienced from the vacuum developed downhole as pressure is released and reapplied that many remedial technologies fail

when transitioned from laboratory to field application. This is a problem that is further exacerbated when it is desired to deliver dissimilar compounds sequentially for appropriate remediation to occur.

SUMMARY OF THE INVENTION

The applicants have devised a closed, pressurized delivery system for in-situ delivery for sub-soil remediation compounds to underground contaminated matter which includes first a liquid diaphragm pump connected to an inflow source of water, the liquid diaphragm pump being also in fluid communication with a plurality of bioslurry tanks connected in parallel, the bioslurry tanks each having a drain. Valve means are located between the first liquid diaphragm pump and each of the bioslurry tanks for controlling either the alternate or simultaneous flow of fluid from the first pump to each of the bioslurry tanks. A second liquid diaphragm pump having an inlet port for receiving the combined flow of the bioslurry tanks has an outlet in fluid communication with a system discharge port. The system further includes a source of compressed gas in fluid communication with the discharge port. A discharge rod is connected to the discharge port for delivery of remedial fluids to underground soils. A gas pressure line leads from a source of compressed gas to the discharge port and is also in fluid communication with a plurality of feed tanks for storage of injectants under pressure, the feed tanks being individually pressurized by the selective fluid communication with the pressure line. Each feed tank includes a separately valved exhaust port connected to the system discharge port such that the source of injectant may be switched from the bioslurry tanks to any of the feed tanks without loss of delivery pressure. The source of pressurized gas may be a mechanical compressor or a stored compressed gas.

The above-described closed delivery system utilizes a combination of gas and liquid delivery systems in which all delivery vessels are interconnected and valved, allowing for mixings, washings, filling, and discharge of materials via pressurized delivery vessels and mechanical pumping systems. The system utilized allows for a variety of dissimilar compounds to be delivered via a single injection line. Further, the switching between feed systems is accomplished without any loss of pressure to the delivery line eliminating the common problems experienced from the vacuum developed down-hole as pressure is released and reapplied. The flexibility, and thus the field success of the system, is due to the unique configuration of gas and liquid feed systems allowing for greater horizontal infiltration below grade and delivery to low permeability soils such as compacted clays which is readily accomplished. Lastly, the current system may be mounted in a mobile trailer, being fully self-contained and requiring no electrical external supply. The only site utility requirement is an available water source for slurry preparation. Other objects and advantages of the present invention will be readily apparent to those of skill in the art from the following drawing and description of the preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1, a preferred apparatus is shown for carrying out the above-described process. The direction of flow is indicated by arrows where appropriate. Not shown are conventional injection rods well-known in the art suitable for subsoil injections which are attached to an injection line in fluid communication with the discharge port **25**.

The bioremediation apparatus of the invention comprises two feed tanks, **T1** and **T2**; two

bioslurry tanks, **LT1** and **LT2**; a liquid diaphragm pump, **P1**; and a second liquid diaphragm pump, **P2**; a gas compressor; and an air storage tank. A liquid feed line from an outside water source is attached to the liquid diaphragm pump, **P1**. The liquid feed lines are also connected to the two bioslurry tanks, **LT1** and **LT2**. From the two bioslurry tanks, **LT1** and **LT2**, a liquid feed line runs to the diaphragm pump, **P2**. The liquid feed line then runs to the two feed tanks, **T1** and **T2**, and out the discharge port **25**.

An inlet air line **21** is attached to the gas compressor. A gas pressure line is attached from the gas compressor to the liquid diaphragm pump **P1** to the two feed tanks, **T1** and **T2**, and out the discharge port **25**. All of the lines are valved, allowing for mixings, washings, filling, and discharge of materials. Valve **V1** is located within the gas line running from the gas compressor toward the outlet. **V2** and **V3** are valves in the liquid line running to feed tanks **T1** and **T2**. Valve **V4** is the liquid line controlling the flow from pump **P2**. Valves **V5** and **V6** are located within the liquid feed line controlling flows from bioslurry tanks **LT1** and **LT2**. **V7** and **V8** are liquid feed valves controlling flows into tanks **LT1** and **LT2**. **V9** is the discharge valve controlling all flow going out of the trailer. **V10** and **V11** are gas feed valves controlling gas flow into feed tanks **T1** and **T2**.

The system is attached to an injection rod which is a hollow, cylindrical pipe (not shown) that has been drilled to a site of underground contamination with a flexible pressure hose. Under high gas pressure, the injection rod is capable of injecting horizontal and vertical pathways underground, both in deep and shallow depths. The steel injection rod has a steel tip used for drilling. In order for the high pressure streams of liquid to be injected, the rod has a series of ports drilled into the lower end of the rod. The injectants can therefore be injected in any

direction.

A specific operation of the apparatus according to one embodiment of the invention may be further described in conjunction with the following process. The process begins by first filling the bioslurry tanks **LT1** and **LT2** and the feed tanks **T1** and **T2**. A source of nitrogen is connected to inlet **21** and a water supply is connected to liquid inlet **23**. Valves **V7** and **V8** are opened which engage an electric actuator to fill bioslurry tanks **LT1** and **LT2**. A micro-nutrients/sodium sulfate is then manually added to the bioslurry tanks **LT1** and **LT2** and allowed to mix. Valves **V7** and **V8** are shut along with disengaging the actuator when the bioslurry tanks are filled.

The injectant preparation phase continues as a pre-mixed heated lactate including vitamins B2 and B12 is manually poured into feed tank **T1**. Valves **V3**, **V4**, **V5**, and **V6** are then opened. Next, pump **P2** is activated and tank **T2** is filled with an appropriate volume of the bioslurry. All valves are closed when finished. Next, zero valent iron is manually added and mixed with the bioslurry in tank **T2**. The tops are then secured on both feed tanks **T1** and **T2** and afterward valves **V10** and **V11** are opened to pressurize both feed tanks. After the injection rod has been properly placed at a selected location, the injection line is secured to discharge port **25** and valve **V9** is opened.

With the injectant preparation phase completed, the injection phase of the process begins. Valve **V1** is opened to create injection pathways until a significant pressure drop is observed at the injection pressure vessel **31** which is filled with the source of compressed gas, preferably either nitrogen or carbon dioxide. Valve **V1** is then closed and valve **V3** opened to introduce the zero valent iron/bioslurry mixture into the subsurface pathways from feed tank **T2**. Valve **V3** is

closed when feed tank **T2** is empty. Next, valve **V2** is opened to introduce the lactate mixture into the subsurface from tank **T1** and is closed after it is empty. It will be understood by those of skill in the art that switching between either the feed tanks or the bioslurry tanks occurs without loss of pressure in the injection line therefore avoiding any down-hole vacuum that would otherwise be experienced in switching from the delivery of one compound to another. This is an important aspect of the invention.

Then, valves **V4**, **V5**, and **V6** are opened to directly deliver bioslurry from tanks **LT1** and **LT2** into the subsurface. All valves are closed when the desired amount of bioslurry has been injected. Finally, in order to cleanse the injection line of the viscous polylactate ester, a reducing agent is once again injected. With the injections complete, a post injection line purge is performed. The gas is injected to clear the lines of any remaining reducing agents. With the lines cleaned, the process is complete and the next injection location is prepared.

It should be understood that there may be other modifications and changes to the present invention that will be obvious to those of skill in the art from the foregoing description, however, the present invention should be limited only by the following claims and their legal equivalents.